PATENT ABSTRACTS OF JAPAN

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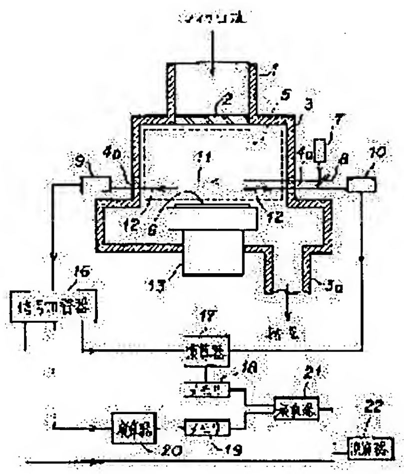
(54) PLASMA MONITOR DEVICE OF PLASMA TREATMENT APPARATUS

(57)Abstract:
PURPOSE: To correctly monitor a plasma state in a treatment chamber and a deposit deposition state on an inner wall of the treatment chamber from outside to correctly monitor change with time in treatment characteristics in plasma treatment by knowing a change on an inner face of a light window from a spectrum distribution obtained by receiving light in a spectrometer.
CONSTITUTION: Reference light is vertically incident to a light window 4a from a reference light source 7 to be received by a spectrometer 9. An output signal containing a state of change on an inner face of light windows 4a, 4b is sent from the spectrometer 9 to a operator 20, and a spectrum distribution of the changed reference light is compared with a spectrum distribution of the reference light source 7. A wafer 6 to be treated is put into a treatment chamber 3 to generate plasma 5, the plasma is made to pass through the light windows 4a, 4b by a plasma emitting path 12 and received by spectrometers 9, 10. If the spectrum distribution of plasma emission obtained by the spectrometer 9 is corrected based on a sum and difference of internal states of the light windows 4a, 4b, light window transmission characteristics from the plasma can be correctly detected.



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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is important section outline drawing of longitudinal section of the 1st example of this invention.
[Drawing 2] It is important section outline drawing of longitudinal section of the 2nd example of this invention.
[Drawing 3] It is important section outline drawing of longitudinal section of the 3rd example of this invention.
[Description of Notations]
2 -- microwave transparency aperture, 3 -- processing room, 4 and 4a, and 4b-- a lantern light, 5 -- plasma, 6 -- wafer, and 6 --' -- a mirror plane wafer, 7 -- reference source, 9, 10 -- spectroscope, and 13 -- a sample base, 14 -- half mirror, 15 -- optical fiber, and 16 -- a signal switcher, 17, 20 and 21, 22 -- computing element, 18, and 19 -- memory.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the plasma monitoring device of suitable plasma treatment equipment to carry out the monitor of the affix deposition situation of the plasma state of the processing interior of a room, and a processing indoor wall with high precision especially with respect to the processing room of plasma treatment equipment which manufactures a semiconductor device, without being influenced of a lantern light.
[0002]
[Description of the Prior Art] Highly precise micro processing is demanded with high integration of LSI. Although the engine performance of each processor of performing the processing is raised of course in order to perform highly precise processing, it is one side and it is important to maintain the engine performance of each processor to long duration stability, and not to take out a defect for a productivity drive.
[0003] In each processor, a substrate installs in the processing interior of a room of the vacuum maintenance structure where of the raw gas for etching is introduced, and if it sees about the plasma-treatment equipment which carries out plasma etching of the front face of this substrate, a resist decomposes during etching processing and the organic substance is generated, and it adheres to a processing indoor wall, or the atom of the metal (molybdenum and tungsten) this [whose] is etched material will serve as film, will adhere to a processing indoor wall, and it will accumulate. If the affix accumulated in the these processing indoor wall touches the plasma, it will generate gas by an operation of the ion in the plasma, or the temperature rise of a processing indoor wall surface, and it changes the penetration condition to the processing room of microwave by adhesion of a metal membrane. The situation of etching processing is changed with time as a result, further, the O ring for vacuum **** of a processing room deteriorates with etching gas, and generates very small leak, and the plasma state is changed.
[0004] Thus, if long duration continuous running of the etching system is carried out, aging of an etching property will occur and it will become the cause of generating of a poor product, and when the affix of a processing indoor wall becomes a certain thickness, it will separate, and it will fall and will exist as a foreign matter. It generated similarly with other plasma treatment equipments (for example, a CVD system, a sputtering system, etc.), and this phenomenon had become a failure when maintaining the engine performance of a processor to long duration stability. for this reason, the etching art which detects a specific spectrum out of plasma luminescence as that cure conventionally, carries out the monitor of the completion time of etching processing from that change on the strength, and presumes a processing property although it is necessary to monitor aging of these processing properties continuously and to predict a defect's generating in advance and the plasma -- a spectrum -- supervisory equipment (for example, JP,56-25972,A, JP,56-133466,A) is propose.
[0005]
[Problem(s) to be Solved by the Invention] In order to take out luminescence from the above-mentioned plasma from the processing interior of a room to the exterior, the aperture called a lantern light is required for the wall of a processing room, but since this lantern light is in contact with the plasma, the phenomenon in which various affixes are accumulated like the above-mentioned processing indoor wall, or a front face is deleted according to a spatter operation of the ion in the plasma accompanies. And this phenomenon advances gradually as aging also in a lantern light. In said conventional technique which takes out luminescence of the plasma to the exterior through this lantern light The phenomenon in which reflect irregularly and the quantity of light decreases is not avoided. that a specific wavelength component is absorbed by the affix accumulated in the lantern light **** -- or a lantern-light front face -- it can delete -- And since it is difficult to presume beforehand change of the spectrum distribution of plasma luminescence which considers these as a cause, it becomes difficult to detect the emission spectrum of the plasma correctly externally. For this reason, it had the trouble which cannot carry out the monitor of the affix deposition situation of the plasma state of the processing interior of a room, and a processing indoor wall correctly from the outside, and cannot carry out the monitor of the aging of the processing property in plasma treatment equipment correctly.
[0006] Moreover, although the number of equipment is the troublesome activity which requires most time amount many, for example cleaning of an affix and inspection of a surface state which were accumulated in this lantern light are conducted by disassembling equipment periodically at about several times of a rate in one month Since it was carried out in the condition that the monitor of the situation or surface state of deposition cannot be carried out correctly, the stage was too early and it also had the trouble which is too late on the contrary and loses an activity and time amount.
[0007] This invention aims at offering the plasma monitoring device in the plasma treatment equipment which can carry out the monitor of the affix deposition situation of the plasma state of the processing interior of a room, and a processing indoor wall correctly from the outside in view of the trouble of the above-mentioned conventional technique, without being influenced of a lantern light, and can carry out the monitor of the aging of the processing property in plasma treatment equipment correctly.
[0008]
[Means for Solving the Problem] The processing room in which the lantern light which this invention has vacuum

purpose was prepared, It has a means to introduce raw gas into this processing room, and the means generating maintenance of the plasma in this processing interior of a room. In the plasma monitoring device of the plasma treatment equipment which processes the wafer on a sample base by this plasma while carrying out the monitor of the generated plasma state The reference source in which an incidence halt is [that spectrum distribution carries out incidence of the light which has a known continuous wavelength component to a lantern light from said processing outdoor] possible, The spectroscope which stops the reference beam and this reference beam before plasma generating from this reference source, and receives the light from the plasma after plasma generating in order the processing outdoor which passed said lantern light, A detection means to detect the lantern-light transparency property of the light from the plasma which consists of an operation means which carries out the comparison operation of each spectrum distribution of said reference beam which received light to this spectroscope, and the light from the plasma is established.

[0009] And the spectroscope which receives the reference beam before plasma generating which the lantern light was made to face said processing room, formed said detection means in it, and passed this each lantern light that carried out relativity, and the light from the plasma which passed one lantern light after plasma generating among said lantern lights which face processing outdoor, It is effective if it is made the configuration which prepares the spectroscope which receives the light from the plasma which passed the lantern light of another side processing outdoor.

[0010] Moreover, the wafer on said sample base is constituted for said detection means exchangeable with a mirror plane wafer. Said lantern light is prepared in the location which faces a wafer or a mirror plane wafer, and a perpendicular. Incidence may be carried out at right angles to the mirror plane wafer on a sample base through the lantern light of this location, and you may make it the configuration which prepares the spectroscope which receives the reference beam before plasma generating which reflected from this mirror plane wafer and passed the lantern light, and the light from the plasma which passed said lantern light after plasma generating processing outdoor.

[0011] Furthermore, said detection means is formed in the location which faces a wafer and a perpendicular in said lantern light. Incidence of the reference beam is carried out from the wafer installation side of a non-laid wafer sample base to said lantern light through the optical fiber laid underground on said sample base. And it is also possible to make it the configuration which prepares the spectroscope which receives the reference beam before plasma generating which has the possible reference source of an incidence halt and passed said lantern light, and the light from the plasma which passed said lantern light after plasma generating processing outdoor.

[0012]

[Function] By having considered as the above-mentioned configuration, first before plasma generating under wafer conveyance etc. If spectrum distribution makes a reference beam light which has known, for example, a continuous wavelength component like the white light, from the exterior of a processing room, a lantern light is continuously introduced and passed to the processing interior of a room and a processing outdoor spectroscope is made to receive light The wavelength component of a proper is absorbed by the matter which constitutes these affixes according to extent of are recording of the film of the organic substance with which the reference beam which passed through the processing room through this lantern light has adhered to the inside of a lantern light, or a metal membrane, and a spectrum changes. How many which wavelength components were absorbed by spectrum change of this reference beam, or the magnitude of attenuation of specific wavelength etc. is detected by it, and a class, deposited thickness of the matter which constitutes said affix are presumed. And the output signal which included the change condition of a lantern-light inside from the spectroscope is sent to an operation means, the comparison operation of the spectrum distribution of the reference beam which this changed, and the spectrum distribution of said known reference source is carried out, and the inside condition of a lantern light is computed.

[0013] If the incidence of a reference beam is stopped next, the actually processed wafer is conveyed to the processing interior of a room, the plasma is generated, a lantern light is passed and a said processing outdoor spectroscope is made to receive the luminescence When it can delete according to a spatter operation of the ion energy from the plasma to a lantern-light inside, ****** occurs and smoothness is lost, according to extent in which the smoothness is lost, the light from the plasma is reflected irregularly regardless of wavelength, and the quantity of light of the whole which passes a lantern light is decreased. Therefore, by detecting the decrement of the quantity of light after a predetermined period from the quantity of light in the condition that smoothness is not lost, a lantern-light inside can be deleted and extent of ****** can be known. thus, the thing for which the spectrum distribution received and acquired to said spectroscope is a thing including the information on the change condition of a lantern-light inside, and the output signal is sent to an operation means -- a lantern-light inside -- it can delete -- etc. -- it can ask for what kind of change extent exerts on the light which passes a lantern light from the plasma.

[0014] Next, the output signal by the light from the plasma after plasma generating sent to the above-mentioned operation means and the output signal by the reference beam including the change of state of the lantern-light inside before said plasma generating calculate with this operation means, and the spectrum distribution of a reference beam is deducted from the spectrum distribution of the light from the plasma. Since this operation value becomes that in which the spectrum distribution of the light from the plasma does not include the change condition of a lantern-light inside, it becomes possible exact and to detect to arbitration, without the lantern-light transparency property of the light from the plasma being influenced by aging of a lantern light. Therefore, it becomes possible to carry out the monitor of the affix deposition situation of the plasma state of the processing interior of a room, and a processing indoor wall correctly from the outside, and to carry out the monitor of the aging of the processing property in plasma treatment equipment correctly.

[0015]

[Example] Hereafter, the example of this invention is explained with reference to drawing 1 thru/or drawing 3 . Drawing 1 is important section outline drawing of longitudinal section of the 2nd example and drawing 3 of important section outline drawing of longitudinal section of the 1st example and drawing 2] important section outline drawings of longitudinal section of the 3rd example.

[0016] The waveguide which introduces into the processing room 3 the microwave oscillated in drawing 1 from the

magnetron which 1 does not illustrate, The microwave transparency aperture by which 2 was prepared in the partition section of a waveguide 1 and the processing room 3, The raw gas the flow of [raw gas] was controlled through the quantity-of-gas-flow regulator which evacuation is carried out through exhaust pipe 3a by the evacuation system which is not illustrated, and holds the vacuum, and is not illustrated is introduced into the processing room 3, and the processing room 3 is held at the predetermined pressure. 4a and 4b are the lantern lights for taking out luminescence from the plasma to the exterior for the purpose of the spectral analysis of the plasma, are made to face the wall of the processing room 3, and are prepared. The plasma which generated 5 by microwave at the processing room 3 of a high vacuum field, the wafer with which 6 was laid on the sample base 13, and 7 are the reference sources to which spectrum distribution can irradiate the light which has known, for example, a continuous wavelength component like the white light. It is installed in the exterior of the processing room 3, and it is constituted so that the reference beam optical path 11 which carried out incidence of the reference beam at right angles to lantern-light 4a, and carried out incidence through the reflecting mirror 8 may be taken out outside through lantern-light 4b which passes through the inside of the processing room 3, and faces. The spectroscope which receives the reference beam from which 9 was taken out through lantern-light 4b outside, and 10 are spectroscopes which receive light in the exterior which passed lantern-light 4a by the plasma luminescence optical path 12 which shows luminescence of the plasma 5 generated where a reference source 7 is stopped in drawing. In this case, luminescence of the plasma 5 which made it generate where a reference source 7 is stopped is received also like a spectroscope 9, after passing lantern-light 4b by the plasma luminescence optical path 12. 16 is a signal switcher which inputs the signal of each spectrum distribution of the output signal from a spectroscope 9, i.e., the reference beam which received light, and the light from the plasma 5, and changes and outputs it to each computing elements 17, 20, and 22 according to the inputted signal. To a computing element 17, the output signal from a spectroscope 10 is also inputted into a signal and coincidence from a spectroscope 9, the difference of both spectrum distribution calculates, and it is inputted into memory 18 here. The computing element with which the computing element with which 20 calculates the difference of the known spectrum distribution of a reference source 7 and the spectrum distribution of the reference beam from said spectroscope 9, and 19 carry out memory of a computing element 20, and 21 carries out the comparison operation of the operation value of computing elements 17 and 20, and 22 are computing elements which amend the spectrum distribution of plasma luminescence obtained with said spectroscope 9 based on the operation value of a computing element 21.

[0017] In the above-mentioned configuration, processing of membrane formation of the wafer 6 laid on the sample base 13, etching, etc. introduces microwave in the direction of an illustration arrow head to the processing room 3 through a waveguide 1 and the microwave transparency aperture 2, and is performed by generating the plasma 5 for processing a wafer 6 in the processing room 3.

[0018] Incidence is carried out to a lifetime at right angles to lantern-light 4a by making into a reference beam light in which spectrum distribution has known, for example, a continuous wavelength component like the white light, from a reference source 7, and lantern-light 4b is continuously introduced and passed to it in the processing room 3, and it is made to receive light to the spectroscope 9 outside the processing room 3 the plasma of five shots under wafer 6 conveyance etc. first in processing of a wafer 6. The wavelength component of a proper is absorbed by the matter which constitutes these affixes according to extent of are recording of the film of the organic substance adhering to the inside of lantern lights 4a and 4b, or a metal membrane, and the reference beam which passed through the processing room 3 through these lantern lights 4a and 4b changes compared with the spectrum of the reference beam in the reference source 7 which does not pass lantern lights 4a and 4b. That is, the difference in this spectrum distribution supported the change of state of the inside of lantern lights 4a and 4b, and how many which wavelength components were absorbed by spectrum change of this reference beam, or the magnitude of attenuation of specific wavelength etc. is detected, and a class, deposited thickness of the matter which constitutes said affix are presumed. And the comparison operation of the difference of the spectrum distribution of a reference beam and the spectrum distribution of said known reference source 7 by which the output signal including the change condition of the aperture inside of two sheets of lantern lights 4a and 4b sent and this changed from the spectroscope 9 to the computing element 20 through the signal switcher 16 is carried out, and the result is inputted into memory 19.

[0019] Next the incidence of a reference beam is stopped, the actually processed wafer 6 is conveyed in the processing room 3, the plasma 5 is generated, lantern lights 4a and 4b are passed by the same plasma luminescence optical path 12, and the spectroscopes 9 and 10 outside said processing room 3 are made to receive the luminescence. The difference of the spectrum distribution acquired with spectroscopes 9 and 10 supports the difference in the inside condition of lantern lights 4a and 4b. When it can delete according to a spatter operation of the ion energy from the plasma 5 to lantern-light 4a and 4b inside, ****** occurs and smoothness is lost According to extent in which the smoothness is lost, the light from the plasma 5 is reflected irregularly regardless of wavelength, and the quantity of light of the whole which passes lantern lights 4a and 4b is decreased. Therefore, by detecting the decrement of the quantity of light after a predetermined period from the quantity of light in the condition that smoothness is not lost, lantern-light 4a and 4b inside can be deleted, and extent of ****** can be known. The signal of the spectrum distribution from a spectroscope 9 is put into a computing element 17 with the signal from a spectroscope 13 through the signal switcher 16, and this difference is memorized in memory 18. Even if it inputs into a computing element 21 the sum and the difference of an inside condition of lantern lights 4a and 4b which were acquired above and inside conditions differ for every information on lantern-light 4a and the inside condition of 4b each, i.e., an aperture, it can know what kind of change will be exerted on the light which passes lantern lights 4a or 4b.

[0020] If a computing element 22 amends the spectrum distribution of plasma luminescence obtained with the spectroscope 9 based on the information on above-mentioned lantern-light 4a and the inside condition of 4b each Since the spectrum distribution of the light from the plasma 5 becomes what does not include the change condition of lantern-light 4a and 4b inside, It can ask for the emission spectrum of the plasma 5, without being influenced of lantern lights 4a and 4b, and it becomes possible exact and to detect to arbitration, without the lantern-light transparency property of the light from the plasma 5 being influenced by aging of lantern lights 4a and 4b. Therefore, it becomes possible to carry out the monitor of the affix deposition situation of the plasma state in the processing room 3, and the wall of the processing room 3 correctly from the outside, and to carry out the monitor of the aging of the processing property in plasma treatment equipment correctly.

[0021] In addition, when the axial symmetry nature of the plasma 5 is good and is considered that the inside condition of lantern lights 4a and 4b is almost the same in this example, the inside condition of lantern lights 4a and 4b can be computed by making the contents of memory 19 into one half, and the contents of memory 17 become unnecessary at this time.
[0022] Below, drawing 2 explains the 2nd example of this invention. The thing of drawing 1 and a same sign shows the same thing among drawing. In drawing, 4 is the lantern light prepared for the same purpose as said 1st example, and is prepared in the location (it sets to this example and is a waveguide 1) which faces the field and perpendicular of a wafer 6 only one place. 14 is the half mirror currently installed between the reference source 7 and the lantern light 4, and introduces the reference beam from a reference source 7 at right angles to the 6th page of a wafer through a lantern light 4.
[0023] In this example, in case the wafer 6 on the sample base 13 is processed, mirror plane wafer 6' is conveyed at intervals of [fixed] the rate of one sheet etc. to 25 processing wafers at the processing room 3, and both the wafers 6 and 6' are constituted exchangeable. The total reflection light of the reference beam from the reference source 7 by which incidence was carried out at right angles to a mirror plane wafer 6'side is taken out outside through a lantern light 4 by the reference beam optical path 11 and this optical path at the time of incidence, and is reflected with a half mirror 14, and light is received with a spectroscope 9. The reflected light spectrum of a reference beam is put into a computing element 20 through the signal switcher 16 in the condition that there is almost no plasma also in this case, the one half of a difference with the spectrum distribution which does not pass the lantern light 4 of a reference source 7 is computed, and it memorizes in memory 19. This shows the effect of a lantern light 4 like said 1st example, and it becomes possible to detect the change of state of lantern-light 4 inside with time. The one half of the difference of said spectrum distribution is computed here for luminescence of the plasma 5 to which the reference beam which incidence was carried out to the mirror plane wafer 6'side, reflected in it in respect of this, and was received by the spectroscope 9 mentions a lantern light 4 later compared with passing twice passing a lantern light 4 only once.
[0024] Next, a reference beam is conveyed by the stop, the actually processed wafer 6 is conveyed on a sample base, and it processes by generating the plasma 5. Luminescence of the plasma 5 at this time is received with a spectroscope 9 through a half mirror 14. In this case, since the spectrum distribution acquired is a thing including the effect of a lantern light 4, if the value of the spectrum distribution which shows the effect of the lantern light 4 which computed using mirror plane wafer 6' and a reference beam previously, and was inputted into memory 19 is deducted with a computing element 22, the lantern-light transparency property of the light from the plasma can be detected correctly, without being influenced of a lantern light 4. Therefore, it becomes possible to carry out the monitor of the affix deposition situation of the plasma state in the processing room 3, and the wall of the processing room 3 correctly from the outside, and to carry out the monitor of the aging of the processing property in plasma treatment equipment correctly like said 1st example.
[0025] Below, drawing 3 explains the 3rd example of this invention. The thing of drawing 1 , drawing 2 , and a same sign shows the same thing among drawing. In drawing, the optical fiber with which 15 was laid under the sample base 13, and 15a are the tips of an optical fiber 15, and the location is the wafer 6 installation side of the sample base 13. In this example, only one place is prepared in the waveguide 1 so that it may become the location which faces the field and perpendicular of a wafer 6 like said 2nd example.
[0026] The reference beam from a reference source 7 is irradiated towards a lantern light 4 through an optical fiber 15 in the state of un-laying a wafer 6 in a condition [without the plasma] 13, i.e., sample base, top from tip 15a (location of an inferior surface of tongue of a wafer 6). A reference beam is taken out outside through a lantern light 4, and is received by the spectroscope 9 through a reflecting mirror 8. And like said 2nd example, it is put into the received reference beam by the computing element 20 through the signal switcher 16, it has a difference with the spectrum distribution which does not pass the lantern light 4 of a reference source 7 computed, and is memorized by memory 19. This shows the effect of a lantern light 4 like said 1st and 2nd example, and it becomes possible to detect the change of state of lantern-light 4 inside with time.
[0027] Next, a reference beam is conveyed by the stop, the actually processed wafer 6 is conveyed on the sample base 13, and it processes by generating the plasma 5. Luminescence of the plasma 5 at this time is received with a spectroscope 9 through a reflecting mirror 8. In this case, since the spectrum distribution acquired is a thing including the effect of a lantern light 4, if the value of the spectrum distribution which shows the effect of the lantern light 4 which computed using the reference beam previously and was inputted into memory 19 is deducted with a computing element 22, the lantern-light transparency property of the light from the plasma can be detected correctly, without being influenced of a lantern light 4. Therefore, it becomes possible to carry out the monitor of the affix deposition situation of the plasma state in the processing room 3, and the wall of the processing room 3 correctly from the outside, and to carry out the monitor of the aging of the processing property in plasma treatment equipment correctly like said 1st and 2nd example. In addition, during wafer 6 processing, in order to become the form where optical fiber tip 15a was covered with the wafer 6 and not to touch the plasma 5, even if it repeats processing, a foreign matter does not adhere to optical fiber tip 15a, or **** does not arise.
[0028] In addition, although this example explained the microwave discharge plasma, it cannot be restricted to this and can be applied similarly [in the case of the high-frequency-discharge plasma or the direct-current-discharge plasma].
[0029]
[Effect of the Invention] The effectiveness which this invention can carry out the monitor of the affix deposition situation of the plasma state of the processing interior of a room and a processing indoor wall correctly from the outside, without being influenced of a lantern light as explained above, and can carry out the monitor of the aging of the processing property in plasma treatment equipment correctly is done so.

[Translation done.]

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ABSTRACT:

PURPOSE: To correctly monitor a plasma state in a treatment chamber and a deposit deposition state on an inner wall of the treatment chamber from outside to correctly monitor change with time in treatment characteristics in plasma treatment by knowing a change on an inner face of a light window from a spectrum distribution obtained by receiving light in a spectrometer.

CONSTITUTION: Reference light is vertically incident to a light window 4a from a reference light source 7 to be received by a spectrometer 9. An output signal containing a state of change on an inner face of light windows 4a, 4b is

sent from the spectrometer 9 to a operator 20, and a spectrum distribution of the changed reference light is compared with a spectrum distribution of the reference light source 7. A wafer 6 to be treated is put into a treatment chamber 3 to generate plasma 5, the plasma is made to pass through the light windows 4a, 4b by a plasma emitting path 12 and received by spectrometers 9, 10. If the spectrum distribution of plasma emission obtained by the spectrometer 9 is corrected based on a sum and difference of internal states of the light windows 4a, 4b, light window transmission characteristics from the plasma can be correctly detected.

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C23F 4/00	A	8414－4K		
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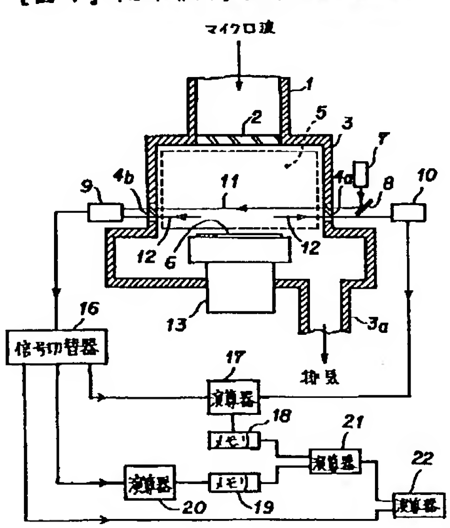
(54)【発明の名称】　プラズマ処理装置のプラズマモニタ装置

(57)【要約】　（修正有）

【目的】　処理室内のプラズマ状態および処理室内壁の付着物堆積状況を、採光窓の影響を受けることなく外部から正確にモニタし、プラズマ処理装置における処理特性の経時変化を正しくモニタすることができるプラズマ処理装置におけるプラズマモニタ装置を提供する。

【構成】　プラズマ処理装置のプラズマモニタ装置において、スペクトル分布が既知の連続的な波長成分を有する光を前記処理室外から採光窓４ａ，４ｂに垂直に入射可能な参照光源７と、該参照光源７からのプラズマ発生前の参照光および該参照光を停止しプラズマ発生後のプラズマからの光を、前記採光窓を通過した処理室外にて順に受光する分光器１０と、該分光器１０に受光した前記参照光およびプラズマからの光の各スペクトル分布を比較演算する演算手段２０，２１，２２とからなるプラズマからの光の採光窓透過特性を検出する検出手段を設ける。

【図1】本発明の第1の実施例の要部概略図



3 ---処理室
4a,4b---採光窓
5 --- プラズマ
6 --- ウエハ
7 --- 参照光源
8 --- 反射鏡
9,10---分光器
13--- 試料台

1

【特許請求の範囲】

【請求項1】真空保持構造を有しプラズマからの発光を外部へ取り出す採光窓を設けた処理室と、該処理室に処理ガスを導入する手段と、該処理室内にプラズマを発生維持する手段とを有し、発生したプラズマ状態をモニタしながら該プラズマにより試料台上のウエハを処理するプラズマ処理装置のプラズマモニタ装置において、スペクトル分布が既知の連続的な波長成分を有する光を前記処理室外から採光窓に入射可能な参照光源と、該参照光源からのプラズマ発生前の参照光および該参照光を停止しプラズマ発生後のプラズマからの光を、前記採光窓を通過した処理室外にて順に受光する分光器と、該分光器に受光した前記参照光およびプラズマからの光の各スペクトル分布を比較演算する演算手段とからなるプラズマからの光の採光窓透過特性を検出する検出手段を設けたことを特徴とするプラズマ処理装置のプラズマモニタ装置。

【請求項2】前記検出手段が、前記処理室に採光窓を相対させて設け、該相対した各採光窓を通過したプラズマ発生前の参照光とプラズマ発生後に前記相対する採光窓のうち一方の採光窓を通過したプラズマからの光とを処理室外にて受光する分光器と、他方の採光窓を通過したプラズマからの光を処理室外にて受光する分光器とを設けてなる請求項1記載のプラズマ処理装置のプラズマモニタ装置。

【請求項3】前記検出手段が、前記試料台上のウエハを鏡面ウエハと交換可能に構成し、前記採光窓をウエハまたは鏡面ウエハと垂直に相対する位置に設け、該位置の採光窓を介して試料台上の鏡面ウエハに垂直に入射し、かつ該鏡面ウエハより反射して採光窓を通過したプラズマ発生前の参照光とプラズマ発生後に前記採光窓を通過したプラズマからの光とを処理室外にて受光する分光器を設けてなる請求項1記載のプラズマ処理装置のプラズマモニタ装置。

【請求項4】前記検出手段が、前記採光窓をウエハと垂直に相対する位置に設け、前記試料台上に埋設した光ファイバを介してウエハ未載置の試料台のウエハ載置面より前記採光窓に対して参照光を入射可能な参照光源を有し、前記採光窓を通過したプラズマ発生前の参照光とプラズマ発生後に前記採光窓を通過したプラズマからの光とを処理室外にて受光する分光器を設けてなる請求項1記載のプラズマ処理装置のプラズマモニタ装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は半導体デバイスを製造するプラズマ処理装置の処理室に係わり、特に処理室内のプラズマ状態及び処理室内壁の付着物堆積状況を、採光窓の影響を受けることなく高精度にモニタするのに好適なプラズマ処理装置のプラズマモニタ装置に関する。

【0002】

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【従来の技術】ＬＳＩの高集積化に伴い、高精度の微細加工が要求されている。高精度の加工を行うためには、その加工を行う各処理装置の性能を向上させることはもちろんであるが、一方で、生産性向上のために各処理装置の性能を長時間安定に維持して不良を出さないことが重要である。

【０００３】各処理装置の中で、エッチング用処理ガスが導入される真空保持構造の処理室内に基板を設置し、該基板の表面をプラズマエッチングするプラズマ処理装置についてみると、エッチング処理中にレジストが分解して有機物が発生し、これが処理室内壁に付着したり、或いは、被エッチング材である金属（モリブデンやタングステン）の原子が処理室内壁に膜となって付着したりして蓄積する。これら処理室内壁に蓄積した付着物は、プラズマに接するとプラズマ中のイオンの作用や処理室内壁面の温度上昇によりガスを発生したり、また、金属膜の付着によりマイクロ波の処理室への進入状態を変化させたりして、結果的にエッチング処理の状況を経時的に変化させ、さらに、処理室の真空封じのためのOリングが、エッチングガスにより劣化して微少なリークを発生しプラズマ状態を変化させたりする。

【０００４】このように、エッチング装置を長時間連続運転していると、エッチング特性の経時変化が起きて製品不良の発生原因となり、また、処理室内壁の付着物は、ある厚みになると剥がれ落ちて異物として存在することになる。この現象は、他のプラズマ処理装置（例えば、ＣＶＤ装置やスパッタ装置等）でも同様に発生し、処理装置の性能を長時間安定に維持する上で障害となっていた。このため、これらの処理特性の経時変化を常時監視し、不良の発生を事前に予測することが必要になるが、従来はその対策として、プラズマ発光の中から特定のスペクトルを検出し、その強度変化からエッチング処理の完了時点をモニタして処理特性を推定するエッチング処理方法やプラズマ分光監視装置（例えば、特開昭５６－２５９７２号公報，特開昭５６－１３３４６６号公報）が提案されている。

【０００５】

【発明が解決しようとする課題】上記プラズマからの発光を処理室内から外部へ取り出すためには、処理室の壁に採光窓と呼ぶ窓が必要であるが、この採光窓は、プラズマに接しているために前述の処理室内壁と同様に種々の付着物が蓄積したり、プラズマ中のイオンのスパッタ作用により表面が削られたりする現象が付随する。そして、この現象は採光窓においても経時変化として徐々に進行する。かかる採光窓を通してプラズマの発光を外部へ取り出す前記従来技術においては、採光窓に蓄積した付着物により特定の波長成分が吸収されたり、或いは採光窓表面の削れにより乱反射して光量が減少する現象が避けられず、しかも、これらを原因とするプラズマ発光のスペクトル分布の変化をあらかじめ推定することが困

難であることから、プラズマの発光スペクトルを外部で正確に検出することが困難になる。このため、処理室内のプラズマ状態および処理室内壁の付着物堆積状況を外部から正確にモニタすることができず、プラズマ処理装置における処理特性の経時変化を正しくモニタすることができない問題点を有していた。

【0006】また、この採光窓に蓄積した付着物の清掃や表面状態の検査は、装置数が多くかなりの時間を要する煩わしい作業であるにもかかわらず、例えば一ヶ月に数回程度の割合で定期的に装置を分解して行われるが、堆積の状況や表面状態を正確にモニタできない状態で行われるため、時期が早すぎたり、反対に遅すぎたりして作業および時間をロスする問題点も有していた。

【0007】本発明は、上記従来技術の問題点に鑑み、処理室内のプラズマ状態および処理室内壁の付着物堆積状況を、採光窓の影響を受けることなく外部から正確にモニタし、プラズマ処理装置における処理特性の経時変化を正しくモニタすることができるプラズマ処理装置におけるプラズマモニタ装置を提供することを目的とする。

【0008】

【課題を解決するための手段】上記目的を達成するため、本発明は、真空保持構造を有しプラズマからの発光を外部へ取り出す採光窓を設けた処理室と、該処理室に処理ガスを導入する手段と、該処理室内にプラズマを発生維持する手段とを有し、発生したプラズマ状態をモニタしながら該プラズマにより試料台上のウエハを処理するプラズマ処理装置のプラズマモニタ装置において、スペクトル分布が既知の連続的な波長成分を有する光を前記処理室外から採光窓に入射し、かつ入射停止の可能な参照光源と、該参照光源からのプラズマ発生前の参照光および該参照光を停止しプラズマ発生後のプラズマからの光を、前記採光窓を通過した処理室外にて順に受光する分光器と、該分光器に受光した前記参照光およびプラズマからの光の各スペクトル分布を比較演算する演算手段とからなるプラズマからの光の採光窓透過特性を検出する検出手段を設けるようにしたものである。

【0009】そして、前記検出手段を、前記処理室に採光窓を相対させて設け、該相対した各採光窓を通過したプラズマ発生前の参照光とプラズマ発生後に前記相対する採光窓のうち一方の採光窓を通過したプラズマからの光とを処理室外にて受光する分光器と、他方の採光窓を通過したプラズマからの光を処理室外にて受光する分光器とを設ける構成にすると効果的である。

【0010】また、前記検出手段を、前記試料台上のウエハを鏡面ウエハと交換可能に構成し、前記採光窓をウエハまたは鏡面ウエハと垂直に相対する位置に設け、該位置の採光窓を介して試料台上の鏡面ウエハに垂直に入射し、かつ該鏡面ウエハより反射して採光窓を通過したプラズマ発生前の参照光とプラズマ発生後に前記採光窓を通過したプラズマからの光とを処理室外にて受光する分光器を設ける構成にしてもよい。

【0011】さらに、前記検出手段を、前記採光窓をウエハと垂直に相対する位置に設け、前記試料台上に埋設した光ファイバを介してウエハ未載置の試料台のウエハ載置面より前記採光窓に対して参照光を入射し、かつ入射停止の可能な参照光源を有し、前記採光窓を通過したプラズマ発生前の参照光とプラズマ発生後に前記採光窓を通過したプラズマからの光とを処理室外にて受光する分光器を設ける構成にすることも可能である。

【0012】

【作用】上記構成としたことにより、まず、ウエハ搬送中などのプラズマ発生前に、処理室の外部からスペクトル分布が既知の、例えば白色光のような連続的な波長成分を有する光を参照光として処理室内に導入し、つづいて採光窓を通過して処理室外の分光器に受光させると、この採光窓を介して処理室を通過した参照光は、採光窓の内面に付着している有機物の膜や金属膜の蓄積の程度に応じて、それら付着物を構成している物質に固有の波長成分が吸収され、スペクトルが変化する。この参照光のスペクトル変化により、どの波長成分がどの程度吸収されたか、或いは特定の波長の減衰量等が検出され、前記付着物を構成している物質の種類や堆積している厚さなどが推定される。そして、分光器から採光窓内面の変化状態を含んだ出力信号が演算手段に送られ、該変化した参照光のスペクトル分布と前記既知の参照光源のスペクトル分布とが比較演算され、採光窓の内面状態が算出される。

【0013】つぎに参照光の入射を停止し、実際に処理するウエハを処理室内に搬送してプラズマを発生させ、その発光を採光窓を通過させて前記処理室外の分光器に受光させると、採光窓内面にプラズマからのイオンエネルギのスパッタ作用により削れや荒れが発生して平滑度が失われている場合は、その平滑度が失われている程度に応じてプラズマからの光を波長に無関係に乱反射し、採光窓を通過する全体の光量を減少させる。そのため、平滑度が失われていない状態の光量から所定期間後の光量の減少量を検出することにより採光窓内面の削れや荒れの程度を知ることができる。このように前記分光器に受光して得たスペクトル分布は、採光窓内面の変化状態の情報を含んだものになっており、その出力信号が演算手段に送られることにより、採光窓内面の削れ等の程度が採光窓を通過するプラズマからの光にどのような変化を及ぼすかを求めることができる。

【0014】つぎに、上記演算手段に送られたプラズマ発生後のプラズマからの光による出力信号と、前記プラズマ発生前の採光窓内面の状態変化を含んだ参照光による出力信号とが該演算手段により演算され、プラズマからの光のスペクトル分布から参照光のスペクトル分布が差し引かれる。この演算値は、プラズマからの光のスペ

クトル分布が採光窓内面の変化状態を含まないものになるため、プラズマからの光の採光窓透過特性を採光窓の経時変化に影響されることなく正確かつ任意に検出することが可能になる。従って、処理室内のプラズマ状態および処理室内壁の付着物堆積状況を外部から正確にモニタし、プラズマ処理装置における処理特性の経時変化を正しくモニタすることが可能になる。

【0015】

【実施例】以下、本発明の実施例を図1ないし図3を参照して説明する。図1は第1の実施例の要部概略縦断面図、図2は第2の実施例の要部概略縦断面図、図3は第3の実施例の要部概略縦断面図である。

【0016】図1において、1は図示しないマグネトロンから発振されたマイクロ波を処理室3に導入する導波管、2は導波管1と処理室3との仕切り部に設けられたマイクロ波透過窓、処理室3は図示しない真空排気系により排気管3ａを通じて真空排気されて真空を保持しており、かつ図示していないガス流量調整器を通じて流量調整された処理ガスが処理室3に導入され所定の圧力に保持されている。4ａ，4ｂはプラズマの分光分析を目的としてプラズマからの発光を外部へ取り出すための採光窓で、処理室3の壁に相対させて設けられている。5は高真空領域の処理室3でマイクロ波によって発生したプラズマ、6は試料台13上に載置されたウエハ、7はスペクトル分布が既知の、例えば白色光のような連続的な波長成分を有する光を照射可能な参照光源で、処理室3の外部に設置され、参照光を反射鏡8を介して採光窓4ａに垂直に入射し、入射した参照光光路11が処理室3内を通過して相対する採光窓4ｂを経て外部へ取り出されるように構成されている。9は採光窓4ｂを経て外部へ取り出された参照光を受光する分光器、10は参照光源7を停止した状態で発生させたプラズマ5の発光を、図に示すプラズマ発光光路12で採光窓4ａを通過させた外部で受光する分光器である。この場合、参照光源7を停止した状態で発生させたプラズマ5の発光は、プラズマ発光光路12で採光窓4ｂを通過させた後、分光器9にも同様に受光される。16は分光器9からの出力信号、すなわち受光した参照光およびプラズマ5からの光の各スペクトル分布の信号を入力し、入力した信号に応じて各演算器17，20，22に切り替えて出力する信号切替器である。ここで演算器17には、分光器9からの信号と同時に分光器10からの出力信号も入力され、両者のスペクトル分布の差が演算されてメモリ18に入力される。20は参照光源7の既知のスペクトル分布と前記分光器9からの参照光のスペクトル分布の差を演算する演算器、19は演算器20のメモリ、21は演算器17および20の演算値を比較演算する演算器、22は演算器21の演算値をもとに前記分光器9にて得たプラズマ発光のスペクトル分布を補正する演算器である。

【0017】上記構成において、試料台13上に載置されたウェハ6の成膜やエッチング等の処理は、マイクロ波を図示矢印方向に導波管1およびマイクロ波透過窓2を経て処理室3へ導入し、処理室3内にウェハ6を処理するためのプラズマ5を発生させて行われる。

【0018】ウェハ6の処理に当たって、まず、ウエハ6搬送中などのプラズマ5発生前に、参照光源7からスペクトル分布が既知の、例えば白色光のような連続的な波長成分を有する光を参照光として採光窓4ａに垂直に入射して処理室3内に導入し、つづいて採光窓4ｂを通過して処理室3外の分光器9に受光させる。この採光窓4ａ，4ｂを介して処理室3を通過した参照光は、採光窓4ａ，4ｂの内面に付着している有機物の膜や金属膜の蓄積の程度に応じて、それら付着物を構成している物質に固有の波長成分が吸収され、採光窓4ａ，4ｂを通過しない参照光源7における参照光のスペクトルに比べて変化する。すなわち、このスペクトル分布の違いは採光窓4ａ，4ｂの内面の状態変化に対応しており、この参照光のスペクトル変化により、どの波長成分がどの程度吸収されたか、或いは特定の波長の減衰量等が検出され、前記付着物を構成している物質の種類や堆積している厚さなどが推定される。そして、分光器9から採光窓4ａ，4ｂの2枚の窓内面の変化状態を含んだ出力信号が信号切替器16を経て演算器20に送られ、該変化した参照光のスペクトル分布と前記既知の参照光源7のスペクトル分布との差が比較演算され、その結果がメモリ19に入力される。

【0019】つぎに参照光の入射を停止し、実際に処理するウエハ6を処理室3内に搬送してプラズマ5を発生させ、その発光を同一のプラズマ発光光路12で採光窓4ａ，4ｂを通過させて前記処理室3外の分光器9および10に受光させる。分光器9，10で得たスペクトル分布の差は採光窓4ａ，4ｂの内面状態の違いに対応しており、採光窓4ａ，4ｂ内面にプラズマ5からのイオンエネルギのスパッタ作用により削れや荒れが発生して平滑度が失われている場合は、その平滑度が失われている程度に応じてプラズマ5からの光を波長に無関係に乱反射し、採光窓4ａ，4ｂを通過する全体の光量を減少させる。そのため、平滑度が失われていない状態の光量から所定期間後の光量の減少量を検出することにより採光窓4ａ，4ｂ内面の削れや荒れの程度を知ることができる。分光器9からのスペクトル分布の信号を信号切替器16を経て分光器13からの信号と共に演算器17に入れ、この差をメモリ18に記憶しておく。以上で得た採光窓4ａ，4ｂの内面状態の和および差を演算器21に入力し、採光窓4ａ，4ｂ個々の内面状態の情報、すなわち、窓ごとに内面状態が異なっていても、採光窓4ａまたは4ｂを通過する光にどのような変化を及ぼすかを知ることができる。

【0020】上記採光窓4ａ，4ｂ個々の内面状態の情

報をもとに、分光器９で得たプラズマ発光のスペクトル分布を演算器２２で補正すれば、プラズマ５からの光のスペクトル分布が採光窓４ａ，４ｂ内面の変化状態を含まないものになるため、プラズマ５の発光スペクトルを採光窓４ａ，４ｂの影響を受けることなく求めることができ、プラズマ５からの光の採光窓透過特性を採光窓４ａ，４ｂの経時変化に影響されることなく正確かつ任意に検出することが可能になる。従って、処理室３内のプラズマ状態および処理室３の内壁の付着物堆積状況を外部から正確にモニタし、プラズマ処理装置における処理特性の経時変化を正しくモニタすることが可能になる。

【００２１】なお、本実施例においてプラズマ５の軸対称性がよく、採光窓４ａと４ｂの内面状態がほぼ同じと考えられる場合には、メモリ１９の内容を半分にすることで採光窓４ａ，４ｂの内面状態が算出でき、このときメモリ１７の内容は不要になる。

【００２２】つぎに、本発明の第２の実施例を図２により説明する。図中、図１と同符号のものは同じものを示す。図において、４は前記第１の実施例と同一の目的で設けられた採光窓で、ウエハ６の面と垂直に相対する位置（本実施例においては導波管１）に１個所だけ設けられている。１４は参照光源７と採光窓４との間に設置されているハーフミラーで、参照光源７からの参照光を採光窓４を介してウェハ６面に垂直に導入するようになっている。

【００２３】本実施例においては、試料台１３上のウェハ６を処理する際に、例えば、処理ウエハ２５枚に１枚の割合等の一定間隔で鏡面ウェハ６′を処理室３に搬送し、両ウエハ６，６′を交換可能に構成している。鏡面ウェハ６′面に垂直に入射された参照光源７からの参照光の全反射光を、入射時の参照光光路１１と同光路で採光窓４を介して外部に取り出し、ハーフミラー１４により反射させ分光器９で受光する。この場合も、まずプラズマの無い状態で参照光の反射光スペクトルを信号切替器１６を経て演算器２０に入れ、参照光源７の採光窓４を通過しないスペクトル分布との差の半分を算出しメモリ１９に記憶する。これは前記第１の実施例と同様に採光窓４の影響を示すもので、採光窓４内面の状態変化を経時的に検出することが可能になる。ここで前記スペクトル分布の差の半分を算出するのは、鏡面ウェハ６′面に入射され該面にて反射して分光器９に受光された参照光が、採光窓４を２回通過するのに比べて、後述するプラズマ５の発光が採光窓４を１回しか通過しないためである。

【００２４】つぎに参照光を止め、実際に処理するウェハ６を試料台上に搬送し、プラズマ５を発生させ処理を行う。このときのプラズマ５の発光をハーフミラー１４を経て分光器９で受光する。この場合に得られるスペクトル分布は、採光窓４の影響を含んだものとなっているので、先に鏡面ウェハ６′と参照光を用いて算出しメモリ１９に入力した採光窓４の影響を示すスペクトル分布の値を演算器２２により差し引けば、採光窓４の影響を受けることなくプラズマからの光の採光窓透過特性を正確に検出することができる。従って前記第１の実施例と同様に、処理室３内のプラズマ状態および処理室３の内壁の付着物堆積状況を外部から正確にモニタし、プラズマ処理装置における処理特性の経時変化を正しくモニタすることが可能になる。

【００２５】つぎに、本発明の第３の実施例を図３により説明する。図中、図１，図２と同符号のものは同じものを示す。図において、１５は試料台１３に埋設された光ファイバ、１５ａは光ファイバ１５の先端で、その位置は試料台１３のウエハ６載置面である。本実施例では前記第２の実施例と同様に、ウエハ６の面と垂直に相対する位置になるように導波管１に１個所だけ設けられている。

【００２６】プラズマの無い状態、つまり試料台１３上にウエハ６が未載置の状態で、参照光源７からの参照光が光ファイバ１５を介してその先端１５ａ（ウェハ６の下面相当の位置）から採光窓４に向けて照射される。参照光は採光窓４を経て外部に取り出され、反射鏡８を介して分光器９に受光される。そして前記第２の実施例と同様に、受光された参照光は信号切替器１６を経て演算器２０に入れられ、参照光源７の採光窓４を通過しないスペクトル分布との差を算出されてメモリ１９に記憶される。これは前記第１，第２の実施例と同様に採光窓４の影響を示すもので、採光窓４内面の状態変化を経時的に検出することが可能になる。

【００２７】つぎに参照光を止め、実際に処理するウェハ６を試料台１３上に搬送し、プラズマ５を発生させ処理を行う。このときのプラズマ５の発光を反射鏡８を経て分光器９で受光する。この場合に得られるスペクトル分布は、採光窓４の影響を含んだものとなっているので、先に参照光を用いて算出しメモリ１９に入力した採光窓４の影響を示すスペクトル分布の値を演算器２２により差し引けば、採光窓４の影響を受けることなくプラズマからの光の採光窓透過特性を正確に検出することができる。従って前記第１，第２の実施例と同様に、処理室３内のプラズマ状態および処理室３の内壁の付着物堆積状況を外部から正確にモニタし、プラズマ処理装置における処理特性の経時変化を正しくモニタすることが可能になる。なお、ウエハ６処理中は、光ファイバ先端１５ａがウェハ６に覆われた形になりプラズマ５に接しないため、処理を繰り返しても光ファイバ先端１５ａに異物が付着したり削れが生じたりすることはない。

【００２８】なお、本実施例はマイクロ波放電プラズマについて説明したが、これに限るものではなく、高周波放電プラズマや直流放電プラズマの場合にも同様に適用することができる。

【００２９】

【発明の効果】以上説明したように本発明は、処理室内のプラズマ状態および処理室内壁の付着物堆積状況を、採光窓の影響を受けることなく外部から正確にモニタし、プラズマ処理装置における処理特性の経時変化を正しくモニタすることができる効果を奏する。

【図面の簡単な説明】

【図１】本発明の第１の実施例の要部概略縦断面図である。

【図２】本発明の第２の実施例の要部概略縦断面図である。

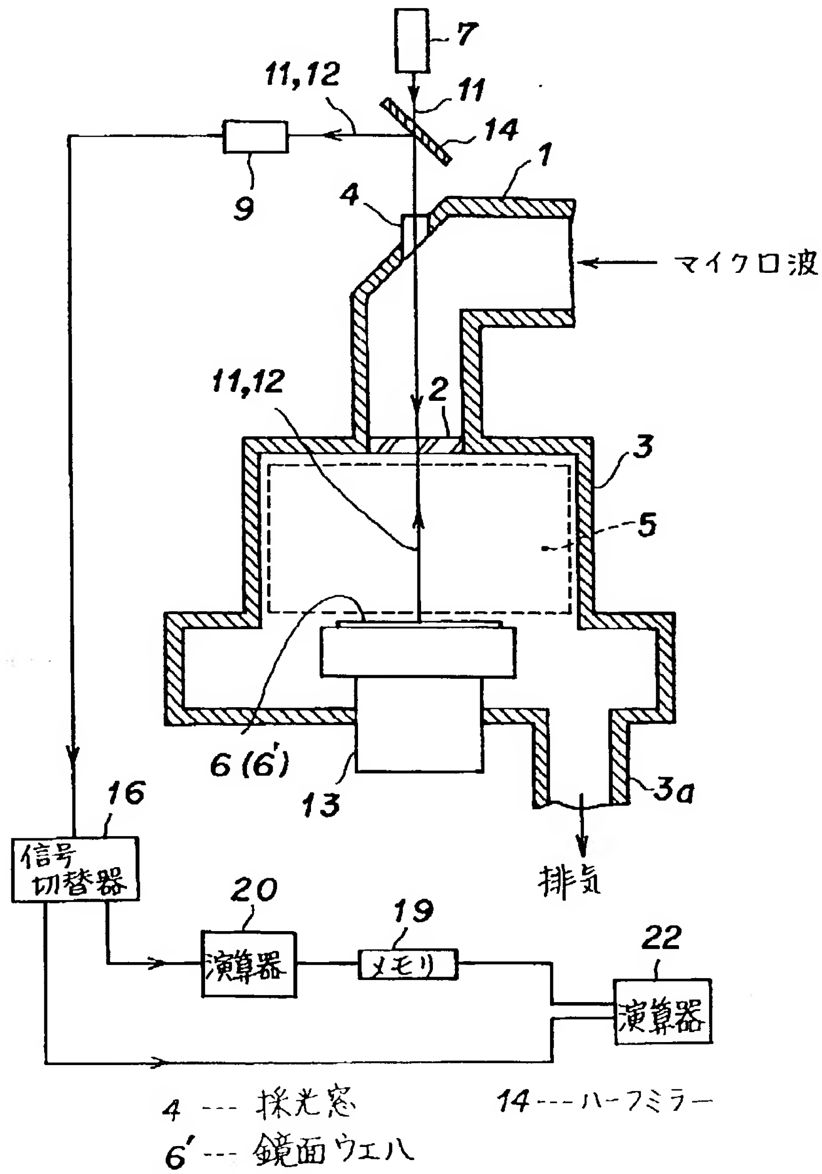
【図３】本発明の第３の実施例の要部概略縦断面図である。

【符号の説明】

２…マイクロ波透過窓、３…処理室、４，４ａ，４ｂ…採光窓、５…プラズマ、６…ウェハ、６´…鏡面ウエハ、７…参照光源、９，１０…分光器、１３…試料台、１４…ハーフミラー、１５…光ファイバ、１６…信号切替器、１７，２０，２１，２２…演算器、１８，１９…メモリ。

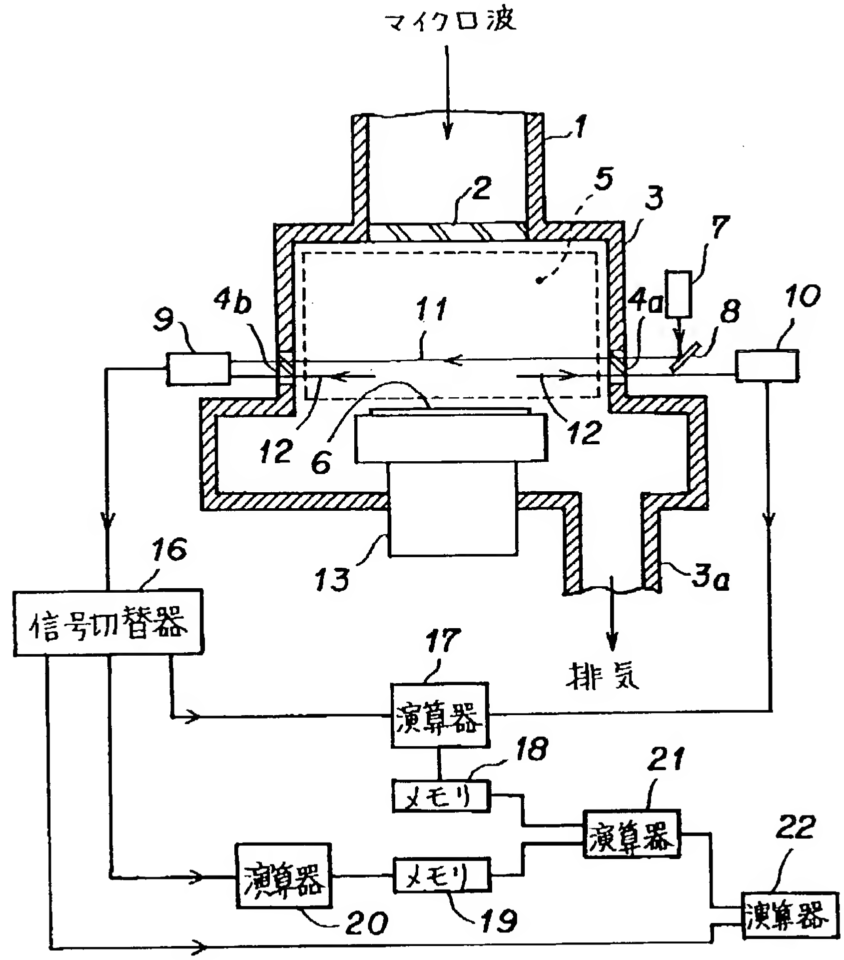
【図２】

【図２】本発明の第２の実施例の要部概略図



【図1】

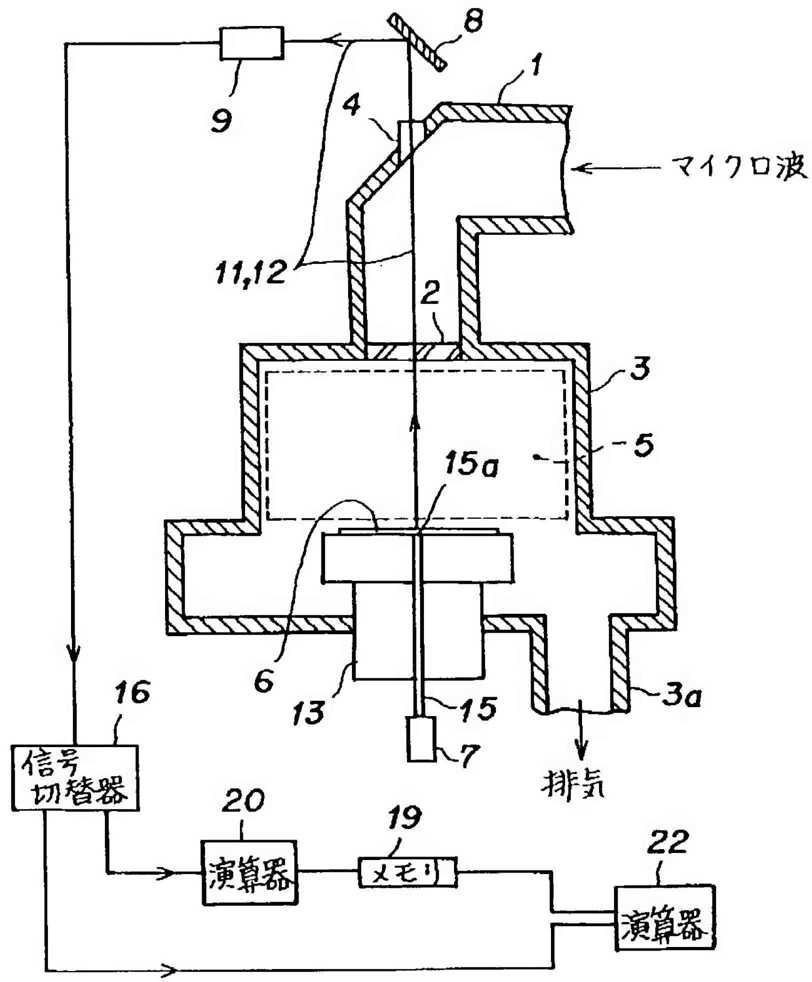
【図 1】本発明の第1の実施例の要部概略図



3 --- 処理室
4a,4b --- 採光窓
5 --- プラズマ
6 --- ウエハ
7 --- 参照光源
8 --- 反射鏡
9,10 --- 分光器
13 --- 試料台

【図3】

【図 3】本発明の第3の実施例の要部概略図



15 --- 光ファイバー
15a --- 光ファイバーの先端

フロントページの続き

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